Development Programs Division
Office of Exploration Systems
National Aeronautics and Space Administration
Washington, DC 20546

MEMORANDUM

RE: Intramural Call For Proposals (ICP)
Human & Robotic Technology
2004

FROM: Deputy Director for Human & Robotic Technology

TO: NASA Center Personnel

RELEASE DATE:	May 14, 2004
NOTICES OF INTENT DUE:	May 21, 2004
PROPOSAL DUE:	June 14, 2004

John C. Mankins

John C, Mankins
Deputy Director for Human & Robotic Technology.
Development Programs Division, Office of Exploration Systems

A. Introduction and Overview

1. Introduction

On January 14, 2004, the President of the United States established a new policy and strategic direction for the U.S. civil space program – establishing human and robotic space exploration as its primary goal, and setting clear and challenging goals and objectives. In response to this charge, the National Aeronautics and Space Administration (NASA) created a new Office of Exploration Systems (OExS) at the Agency's headquarters and created or realigned several major programmatic budget themes. The Development Programs Division of OExS is responsible for the formulation and management of the new NASA exploration budget themes: Project Constellation (i.e., the transportation systems theme) and the Human and Robotic Technology (H&RT) Theme. Please refer to H&RT Formulation Plan Version 2.0 for more information on NASA's 'vision for space exploration,' including specific goals and objectives, OExS's overview of spiral development, etc. A copy of the Formulation Plan may be obtained by contacting the appropriate Element Program Lead listed in the Section B of this call.

2. Overview

This Intramural Call for Proposals (ICP) solicits research and technology development proposals from NASA investigators in support of the following H&RT Programs:

- <u>Advanced Space Technology Program (ASTP)</u> (formerly the Mission and Science Measurement Technology (MSMT) program). This program provides the broad, low-TRL foundation for much of NASA space technology. Element Programs within ASTP are described in Section B of this document, along with details of the ASTP proposal topics invited through this ICP. The typical objective of projects funded in ASTP will be to reach a TRL of 4 to 5 by project completion in 2008. Within the ASCT Element Program (described in Section B.1.1), this guideline only applies to Tools; Studies and Advanced Concepts funded through the ASCT Element Program will typically reach lower TRLs by project completion in 2008.

- <u>Technology Maturation Program (TMP)</u>. This is a new program to develop and validate novel systems concepts and high-leverage technologies to enable safe, affordable, effective and sustainable human and robotic exploration, while filling critical gaps in near-term capabilities. Element Programs within TMP are described in Section B, along with details of the TMP proposal topics invited through this ICP. The typical objective of projects funded in TMP will be to reach a TRL of 6 by project completion in 2008. This guideline does not apply to the InSTEP Element Program (described in Section B.2.5).

- <u>Innovative Technology Transfer Partnerships (ITTP) Program</u>. A collection of programs that includes NASA's Small Business Innovation Research (SBIR) program; it seeks to enable the creative use of intellectual assets both inside and outside NASA to meet Agency needs and to benefit the Nation. Element Programs within ASTP are described in Section B of this document. While ITTP proposal submission will be conducted as described in Section F of this call, evaluation of these proposals will be independent of the process described in Section G. For information regarding ITTP Proposals, please contact Mr. Benjamin Neumann (benjamin.j.neumann@nasa.gov; 202-358-2320).

Please contact Mr. John C. Mankins, Deputy Director of the OExS Development Programs Division for H&RT, (john.c.mankins@nasa.gov; 202-358-4659) with general questions concerning the H&RT Theme and/or this ICP. A list of frequently asked questions and answers will be maintained at http://research.hq.nasa.gov/code_t/icp/index.html.

3. Evaluation Criteria

Evaluation criteria will include: (1) relevance to NASA's H&RT objectives, (2) technical merit, (3) cost, (4) management plan (including incorporation of appropriate teaming among NASA Centers and with other organizations), and (5) special factors (such as readiness to begin a focused technology project). A point of particular importance will be the development of appropriate partnerships among NASA Centers in proposed participation in the H&RT projects; these should include both collaborations among research organizations, as well as collaborations involving research organizations and development organizations (to promote the adoption of novel concepts and new technologies). Center-to-center collaborations will be considered both on a case-by-case basis for each project, and in developing an overall H&RT portfolio that is well balanced.

Proposals must also be appropriate to the overall scope of the H&RT program to receive consideration. The following technical goals and objectives will provide the principal basis for determining relevant to NASA H&RT objectives.

3.1 Technical Goals and Objectives

3.1.1 Spiral Development of Exploration Systems

R&D project proposals offered in response to this ICP must be in support with the goals, objectives and approach to human and robotic technology detailed in the H&RT Formulation Plan. This includes a requirement that the timeliness of projected accomplishments must consistent with The National Vision for Space Exploration, the published details of the OExS approach to 'spiral development' to realize the National Vision, including:

(1) A 2014 first crewed flight of a new Crew Exploration Vehicle (CEV),

(2) A human lunar return (HLR) by no later than 2020; and,

(3) Projected possible later 'spirals' as documented in the Formulation Plan.

No formal set of future human/robotic exploration 'design reference architectures' (DRAs) has been established. However, for general information concerning typical concepts or the trade space of system options, offerors may refer to recent studies sponsored by the OExS

Requirements Division, as well as novel concepts examine by the Office of the NASA Space Architect, NASA Exploration Team (NEXT)-sponsored studies, and others.

Selections will be made consistent with the objective of appropriately supporting these future exploration events, as detailed in the Formulation Plan (and its key references).

3.1.2 Strategic Technical Challenges

Proposals must be in response to the strategic challenges that must be surmounted to enable sustainable future exploration—including the goals of affordability, reliability/safety and effectiveness. The H&RT strategic technical challenges (STCs) are intended to frame both 'systems-of-systems' level goals and objectives, and 'subsystem-level' goals and objectives for the program. These challenges are presented in more detail in the H&RT Formulation Plan (Section 6).

Selections will be made consistent with the objective of appropriately supporting these STCs, as detailed in the Formulation Plan (and its key references).

3.1.3 Technology Investment Portfolio Balance

The human and robotic technology investment portfolio resulting from this—and subsequent—solicitations will be consistent with the overall 'portfolio balance' presented in Section 6 of the Formulation Plan. Selections will be made consistent with the targeted portfolio balance. (Note that a portion of future Technology Maturation Program resources will be reserved to support a later competitive process during Winter 2004/2005 that will address critical 'technology gaps' that may be identified through OExS in-house and contractor team studies during coming months.)

Selections will be made consistent with the objective of appropriately supporting these future exploration events, as detailed in the Formulation Plan (and its key references).

The following are the specific guidelines associated with the several programs of the ASTP, TMP and ITTP as they are being formulated through this ICP.[1]

---

[1] Note that there may be substantial changes in the details of the invited topics provided here in any future competitive solicitation associated with H&RT, including both intramural calls for proposals (such as this one), or extramural calls (e.g., through a NASA Research Announcement (NRA), Broad Agency Announcement (BAA), or other means). The validity of the details provided in this ICP is limited to the NASA-led proposals that will result from this call for proposals.

B. Research and Development Area Descriptions

1. Advanced Space Technology Program

Program Director, Dr. Terry Allard at Terry.Allard-1@NASA.gov

1.1 Advanced Studies, Concepts, and Tools (ASCT)

OExS Element Program Lead: Yuri Gawdiak at yuri.o.gawdiak@nasa.gov

This Element Program explores revolutionary exploration technology/systems concepts and architectures; performs technology assessments to identify and prioritize mission enabling technologies; develops advanced engineering tools for systems analysis and reducing mission risk; and conducts exploratory research and development of emerging technologies and novel systems concepts with high potential payoff. This Element Program will provide cross-cutting support in these areas to the several H&RT programs, as well as to the goals of overall H&RT program integration.

Proposals are sought in the technical themes listed below. A proposal may address project topics related to one or more of these themes.

- Advanced Concepts
- Technology-Systems Analysis
- Technology Databases
- System Design and Engineering Analysis Tools

ASCT faces several key challenges in being able to implement a systematic, reliable, and efficient analysis capability for H&RT (and OExS in general). For example, there is ongoing difficulty in acquiring and generating quantitative requirements involving highly complex "trade-space" considerations, visualization of new concepts, and evaluation methods. In addition, rigor in analysis depends upon access to domain data, management of data pedigrees, and consistently dealing with heterogeneous engineering data across diverse systems/missions/architectures. The overall 'portfolio' of investments within ASCT will be managed so as to best address both longer-term opportunities and nearer-term needs to best inform and support the overall needs of H&RT.

The following challenges are of particular importance.

Advanced Concepts. It is important to maintain a steady flow of innovation into the a long-term campaign of sustainable space exploration, and the H&RT investment portfolio in particular. This area will provide an ongoing source of high-leverage, higher-risk concepts and technology opportunities with long-term 'systems-of-systems' level impact. In addition, these 'advanced concepts' efforts could involve not only 'paper studies' but also lower TRL (e.g., TRL 2-3) exploratory research and development involving emerging technologies with high potential payoff through experimental and/or analytical validation; etc.

Technology-Systems Analysis. In addition, it is important that the ongoing technology investment and validation process be guided by focused technology assessments and analyses. These studies are needed in areas involving all of the various other Element Programs within H&RT (including both ASTP and TMP). This Element Program will include advanced studies, technology assessments and forecasts; the development of high-level technology analysis tools, integrated analyses of the potential system and/or architecture impact of new technologies, etc. This area should also encompass support for technology road map definition. Specific proposed efforts could address any of the separate Element Programs, or appropriate cross-cutting combinations of them.

Technology Databases. A strong, integrated approach to the management of technology related information is important to a well-formulated investment portfolio. This Element program will support funding for various types of technology databases, for both internal use in analyses and planning, as well as for external communications. This may involve the identification and management of data related to requirements for technology testing, verification and validation based on architectures, concepts of operations, PRA assessments, etc., and will complement existing capabilities.

System Design and Engineering Analysis Tools. This Element Program also addresses simulation modeling environment, databases, system models, discipline-oriented analysis tools, parametric-based risk analysis and tools, probabilistic risk analysis (PRA), etc. In order to maximize the credibility of the systems analysis efforts within ASCT particular early emphasis related to this area will be placed on data management, baselining, and verification and validation techniques. This effort will be closely coordinated within the larger, Code T CIO efforts, in establishing the enterprise's information architecture, standards, and processes. Additionally another near term priority is to help support the implementation in the agency's planned simulation based acquisition process. Identifying state-of-art gaps and near term solutions to implementing this capability will be aggressively pursued.

Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

1.2 Advanced Materials and Structural Concepts (AMSC)

OExS Element Program Lead: Christopher Moore, Ph.D. at christopher.moore@nasa.gov

This Element Program develops high-performance materials for vehicle structures, propulsion systems, and spacesuits; structural concepts for modular assembly of space infrastructure and large apertures; lightweight deployable and inflatable structures for large space systems and crew habitats; and highly integrated structural systems and advanced thermal management technologies for reducing launch mass and volume. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- Advanced Materials
- Structural Concepts, Dynamics and Controls
- Mechanisms and Interconnects

- Flexible Fiber Systems
- 'Smart' Materials and Structures
- Space Environments and Effects

The following challenges, representative systems and needed technologies, are of particular importance.

Materials. Aerocapture and atmospheric entry systems will need advanced ablative and reusable thermal protection system (TPS) materials. Crew entry vehicles will need concepts for in-space repair of TPS. Advanced spacesuits will need flexible fabrics with high thermal conductivity, and aerogel thermal insulation. Launch vehicle and aeroshell structures will need high strength-to-weight and high temperature composite materials. Habitats, spacesuits, and crew vehicles will need self-healing seals, wire insulation, and structural materials. Habitats, vehicles, and surface systems will need multifunctional materials with integral electronics, sensors, and actuators to monitor system health and adapt to damage and changing mission conditions.

Structures. Large solar power systems, space transportation systems, and large apertures will need structural concepts for in-space assembly from modular elements. Propellant depots and space transportation systems will need lightweight composite and deployable cryotanks with integral thermal management. Habitats and surface systems will need deployable and inflatable structures with integral radiation shielding, thermal management, and health monitoring.

Mechanisms and Interconnects. Modular assembly of large space systems and surface systems will need technologies for in-space welding, bonding, joining, and repair of structural components. Such operations could also benefit significantly intelligent and reconfigurable structural, electrical, and fluid interfaces. A related requirement will exist for a range of future robotic systems which must operate in extreme environments; these systems will require advances in both mechanisms, interconnects and actuators to improve significantly their capabilities and reliability.

Space Environments and Effects. A wide range of topics related to space environmental effects (SEE) must be pursued during the coming years. For example, exploration systems operating in the inner solar system will need integrated space environment models (radiation, meteoroids, charging, etc). Similarly, exploration systems operating on the moon and Mars will need models of surface environments. In addition, exploration systems operating on the moon and Mars will need technologies for mitigating dust and electrostatic charge accumulation.

Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

1.3 Communications, Computing, Electronics and Imaging (CCEI)

OExS Element Program Lead: Barbara Wilson, Ph.D. at bawilson@mail.jpl.nasa.gov

This Element Program develops advanced space communications and networking technology; high-performance computers and computing architectures for space systems and data analysis; low-power electronics to enable robotic operations in extreme environments; and imaging sensors for machine vision systems and the characterization of planetary resources. The special focus is on new devices and components for use in future space systems. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- General Purpose Computing and Data Storage
- Switches, Networks and Internal Communications
- Photonics-Based Computing and Sensing
- Advanced Electronics
- Advanced Sensor Concepts
- MEMS Applications
- Advanced Space Communications

The following challenges are of particular importance.

Modular Fault-Tolerant Spacecraft Computing and Avionics Architecture. Future spacecraft systems will require a new modular approach to integrating the sensor and actuator control, telecommunications, command and data handling, and on-board processing into a scalable architecture that can be adapted for small autonomous robotic surface vehicles as well as large autonomous and human piloted transport vehicles. The architecture should minimize the wiring needed to connect sensors to processing to telecom, support real-time control and complex autonomy processing, and be fault tolerant and "self healing" to some number of single point failures. Components that comprise this architecture should have intelligent and robust interfaces that enable them to "plug and play" with other components in the system. Some specific technology potential interest could include:

- High-speed, fault-tolerant, self-organizing networks and protocols
- Plug and play interfaces suitable for spacecraft systems
- Fault-tolerant distributed operating system layers for heterogeneous network processing and sensing components, with guaranteed quality of service for real-time critical tasks
- Innovative approaches to reducing wiring complexity (both power and data) while maintaining high-bandwidth and low-latency data transfer among components

Radiation and Fault-Tolerant Processing Components. Develop new radiation-tolerant and fault tolerant components for reliable in-space processing with performance comparable to ground-based commercial processors. Processing components should be complete modular elements that communicate with other parts of the spacecraft via a high-speed bus or network, and are self configuring. All components must have a design lifetime radiation TID of at least 100 Krads. Areas anticipated for development include:

- Reconfigurable processor components with power efficiency comparable to commercial devices
- Network-enabled general purpose computing components with power performance and throughput comparable to commercial embedded systems
- Volatile and non-volatile memories and mass storage
- Network and I/O technologies including switches, phase-lock loops and serializers/deserializers to support bandwidths beyond 10 GB/s
- Microcontroller components for interfacing with and controlling sensors and actuators

Ground-Based Computational Efficiency. Design, prototype at sub-scale, and model at full-scale an advanced computing architecture that achieves a 100X improvement in computational efficiency (sustained GFlops/$) over a benchmark execution of a large-scale, multi-physics ExE application on a conventional supercomputer. The scope of this work includes novel computing hardware architecture design, lightweight runtime kernels to logically integrate the envisioned wide array of highly replicated functional elements, optimal exploitation of the advanced hardware architecture to improve application sustained performance, accurate assessment of the system architecture for key ExE applications, and reliable predictions of application performance on large-scale instances of such architectures. Technologies of interest include supercomputing based on: Microcontroller components for interfacing with and controlling sensors and actuators; Processor-in-memory (PIM); Streaming; Field-programmable gate arrays (FPGAs); Graphics processing units (GPUs); and, Other highly-parallel, high memory-bandwidth emerging architectures

Space Communications Backbone and Wide Area Networks. Reliable space communications and networking technologies are needed to support emerging spectrum allocations in the microwave and optical regimes for Lunar/Mars human and robotic mission applications. The bi-directional high capacity space backbone can extend from Earth and or Earth orbit to planetary surfaces and orbits. High rate technologies are needed from planetary assets to orbiters, inter-communications between orbiters, crew transit vehicles, and relays. The goal is to achieve sustainable, scalable, fully accessible and fully reliable communications and navigation infrastructure within the solar system for multiple robotic and human assets wherever they are deployed. In addition the infrastructure will support navigation and multiple communications applications requiring multiplexed two way links of varying data rates that incorporate intelligence, and request service when necessary between deployed multiple surface mission entities and space-based assets. Technologies of interest include:

- High power, high efficiency transmitter technologies and components
- Ultra sensitive receiver/receive arrays
- Technologies to increase data rates by orders of magnitude with reduced overall cost
- Network and protocol innovations to address high-delay links
- Reconfigurable, modular high-rate radio/arrays

- Networks, protocols, and software radio based technologies for flexible, energy efficient, multi access applications.

Surface Wireless Local Area Networks. Dynamic-bandwidth communications and integrated navigation solutions for challenging human and robotic missions and operations on planetary surfaces based on both commercially available wireless technologies and where needed, custom developed components are required. The goals are to support navigation and multiple communications applications requiring multiplexed two-way links of varying data rate for deployed surface mission entities including but not limited to robots, rovers, landers, habitats and personnel. Technologies of potential interest could include: modular, high-capacity, energy-efficient, miniature integrated components for physical, data and network link layer applications; and, power-saving, ad-hoc, and link protocol technologies which are reliable in the space environment

Extreme Environment Imaging Sensors. The extreme thermal environments of the Moon and Mars preclude the use of most terrestrial sensors, their control electronics, actuators, and packaging. A project to develop megapixel imaging systems with high-resolution digital output streams serves as a testbed to overcome these challenges. Technologies of interest include: Visible and IR arrays capable of operating in the Moon environment (generally -180-+120 C, and –230 C in shadowed craters) without thermal control; Low-temperature multiplexors and integrated analog and mixed signal pre-processing elements; Modular electronics packages including power, command and control, and processing functions; Motors and actuators capable of operating over wide temperature ranges; and, High-density packaging approaches tolerant to extreme temperatures and frequent thermal cycling.

In-Space Inspection Sensor Suite. The capability to perform a wide variety of local inspection operations will be important to the long-term, robust operation of diverse systems in deep space and planetary venues. To enable this capability, an integrated suite of imaging sensors for in-space system inspection (to include sensing technologies) are needed, involving diverse novel technological approaches, including: High-density packaging approaches tolerant to extreme temperatures and frequent thermal cycling; Morphology and shape of the system under study, with sufficient resolution to compare to nominal models of the systems for detection of faults; Temperature profile across the surface, and any thermal indications of the condition below the surface of the structure; Spectroscopic identification of the material being imaged, and in particular note the presence of anomalous substances (e.g. cooling fluid, lubricants, etc.); Penetrating imaging to determine the condition of subsurface material conditions, interfaces, laminations, and seals (e.g. check for delaminations of ceramic heat shields from underlying structures); and capabilities to Interact with simple markers embedded or applied to structural elements to gather information that requires material interaction (e.g. a colormetric material that changes color according to strain, interrogated by the imaging system)

Laser Sources and Active Sensors. Exploration systems will need capabilities to map planetary terrain, to avoid surface hazards, to profile planetary atmosphere for controlled aeroentry systems, and to perform ranging, 3D imaging and motion sensing for automated rendezvous and docking and for robot-assisted assembly and surface operations. These capabilities can be provided by improving the efficiency, tunability, and reliability of lasers, and by developing radiation-tolerant imaging lidar systems that operate across a wide range of temperatures. Related advances will also benefit high-bandwidth optical communication links. Technologies of interest include: High-efficiency, high-reliability high-power solid state lasers and diode laser arrays; Tunable lasers at wavelengths in the visible and IR; Sensitive detector arrays with pixel-level ranging; 3D imaging lidar systems; Optical converters; High-efficiency optical receiver, scanner and detector systems

Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

1.4 Software, Intelligent Systems, and Modeling (SISM)

Element Program Lead: Butler Hine, Ph.D. (OExS) (at Butler.P.Hine@nasa.gov).

This Element Program develops reliable software and revolutionary computing algorithms; intelligent systems to enable human-robotic collaboration; intelligent and autonomous systems for robotic exploration and to support human exploration; and advanced modeling and simulation methods for engineering design and data analysis. This Element will also be the focal point for H&RT utilization of NASA or other national supercomputing assets. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- Autonomy and Intelligence
- Human-Automation Interaction
- Multi-Agent Teaming
- Software Engineering for Reliability
- Health Management Technologies
- Modeling, Simulation, and Visualization

The following challenges are of particular importance.

Autonomy and Intelligence. SISM seeks projects which will demonstrate an autonomous control system capable of operating either: (i) a planetary surface vehicle performing scouting or construction activities, (ii) a complex life support or ISRU plant, or (iii) a robotic astronaut assistant working in close proximity with a suited or unsuited astronaut.

Crew-Autonomy Interface Technologies. SISM seeks projects which will demonstrate the applicability of rich multi-modal human interface systems (visual, haptic, speech, etc.) to problems such as: (i) human-robotic on-orbit assembly of structures, (ii) distributed anomaly response systems for advanced life support or vehicle emergencies, or (iii) robotic planetary surface exploration assistants for EVA astronauts.

Multi-Agent Teaming. SISM seeks projects which will demonstrate the applicability of multi-agent technologies to problems such as: (i) crew resource self-scheduling systems, (ii) distributed decision-support systems for advanced life support or vehicle emergencies, or (iii) multi-robotic teams constructing planetary or orbital facilities.

Software Engineering. SISM seeks projects which will demonstrate the applicability of advanced software engineering technologies to problems such as: (i) increased software reliability for critical flight control software, (ii) modular and reusable flight software, or (iii) software verification and validation techniques for autonomous systems.

Health Management Technologies. SISM seeks projects which will demonstrate the applicability of health management technologies (fault detection, diagnosis, prognostics, information fusion, degradation management, etc.) to problems such as: (i) crew emergency response advisory systems, (ii) on-demand vehicle maintenance scheduling, or (iii) automated spacecraft health self-assessment.

Modeling, Simulation, and Visualization. SISM seeks projects which will demonstrate the applicability of modeling, simulation, and visualization to problems such as: (i) end-to-end mission simulation in moderate fidelity, (ii) highly dynamic mission phases in high-fidelity, or (iii) automated model generation and updating design life-cycle tool frameworks.

Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

1.5 Power, Propulsion, and Chemical Systems (PPCS)

Element Program Lead: Christopher Moore, Ph.D. (OExS) at christopher.moore@nasa.gov

The Element Program develops high-efficiency power generation, energy storage, and power management and distribution systems to provide abundant power for space and surface operations; advanced chemical, electrical, and nuclear space propulsion systems for exploration missions; chemical systems for the storage and handling of cryogens and other propellants; chemical systems for identifying, processing, and utilizing planetary resources; and chemical detectors and sensors. Proposals are sought consistent with the technical themes listed below. A proposal may address one or more of these themes.

- Energy Conversion
- Power Management and Distribution
- Energy Storage
- Thermal Management
- Thermal-. Electrical and Chemistry-based Processing of Materials
- Advanced Chemical Propulsion
- Advanced Electric/Electromagnetic Propulsion
- Launch Assist and Other Novel Propulsion Concepts
- Novel Power and Transmission Technologies

The following challenges, including representative systems and needed technologies are of particular importance.

Power. Power systems with the capability for growth will need modular solar arrays that can be assembled into larger systems. Large solar and nuclear power generation systems will need modular, intelligent power management and distribution systems that can be reconfigured to accommodate faults and changing loads. Spacesuits and mobile systems will need high energy density power sources such as advanced batteries and fuel cells. Space utilities that supply power to multiple users will need wireless power transmission systems.

Propulsion. Landers and ascent vehicles will need small variable thrust chemical rocket engines. Microspacecraft scouts and inspectors will need micro-chemical propulsion systems with thrust-to-weight greater than 1000. Propellant depots and space vehicles on long-duration missions will need high energy, storable propellants. Large solar electric and nuclear electric propulsion systems for transporting cargo and crew will need electric thrusters with output power greater than 500 kW. Small launch vehicles will need electromagnetic launch assist systems with 50 metric ton capability to reduce propellant mass and increase payload to orbit. Reducing the trip time for human exploration missions beyond Mars will need revolutionary propulsion system concepts.

Chemical Systems. In Situ Resource Utilization systems will need automated systems to collect lunar regolith for use in the production of consumables; Surface power systems, and vehicle refueling stations will need new processes to produce oxygen and hydrogen from lunar regolith, and new processes to produce propellants and other consumables from the Mars atmosphere; The *in situ* characterization of planetary resources will need miniature, highly integrated chemical analysis systems.

Thermal Management. Lunar surface systems operating at mid-day will need heat pumps capable of rejecting heat to hot environments (300K) with 50 ^{o}C temperature differential. Large space power and propulsion systems will need advanced spacecraft radiators with heat rejection capability greater than 1000 W/kg. Spacesuits, habitats, and mobile systems will need multi-zone, reconfigurable thermal control systems. Propellant depots and transport vehicles will need thermal management systems for ultra-low boil-off cryotanks.

Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

2. Technology Maturation Program

Program Director (acting), John C. Mankins at john.c.mankins@nasa.gov

TMP projects established through this ICP will develop and demonstrate new technologies and concepts at the systems level with the intention of validating (or invalidating) them for transition to future systems development projects within Project Constellation or other (in the case of technologies of broad, cross-cutting value) NASA development programs.

During the initial H&RT 'cycle of innovation' (i.e. during FY 2005-2008), TMP projects should focus on establishing the viability (or non-viability) by 2011 of new, space-based system-of-systems level approaches to Earth-Moon operations to support decisions regarding how to return humans to the Moon by 2020. Technologies that address longer-term challenges, including advanced lunar surface operations and inner Solar System (e.g. Mars) exploration missions are also of interest, but may be expected to be of lower overall emphasis in the resulting investment portfolio. TMP projects that establish a foundation of test beds and test articles that enable the later infusion and validation of various technologies at lower stages of technology validation (e.g. lower TRL products from ASTP) will also be emphasized.

In addition to the projects created through this ICP and the planned NASA Broad Agency Announcement (BAA) for extramural projects, an additional call for TMP projects is planned for Winter 2004/2005, following completion of various studies and requirements development efforts, to be performed by NASA (e.g. Office of Exploration Systems, Requirements Division) and external organizations.

For this ICP, the following are the specific guidelines for project proposals within each of the TMP Element Programs.

2.1 High Energy Space Systems (HESS) Technology

Element Program Lead: Nantel Suzuki (OExS); at nantel.h.suzuki@nasa.gov.

This Element Program examines a range of key technology options associated with future space exploration systems and architectures that are 'energy rich'—including high power space systems, highly efficient and reliable space propulsion systems, and the storage, management and transfer of energy/propellants in space. It may also address (as appropriate) high-energy maneuvering; including aero-entry, aero-braking, and other aero-assist related R&D. Key objectives will derive from the goals of safe/reliable, affordable and effective future human and robotic space exploration in support of the U.S. Vision for Space Exploration. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- High-Efficiency, Low-Mass Solar Power Generation Systems
- Highly-Reliable/Autonomous Deep-Space Cryogenic Propellant Refueling Systems
- High- Efficiency/Power and Low-Mass Electromagnetic (EM) Propulsion Systems
- Deep-Throttling Multi-Use In-Space Cryogenic Engines

- Large, low-mass aeroassist systems
- Novel, high-energy space systems demonstrations

HESS projects established through this ICP should abide by the general TMP guidance provided above, and should focus on modular, high-energy concepts for use in long-lived in-space infrastructures, transportation systems, and surface systems. One of the central strategic technical challenges for HESS is to validate (or invalidate) by 2011 the system-of-systems level concept of reusability as it applies to a variety of high energy systems. The challenge is to use vehicles and systems during multiple phases of a single mission, and/or over multiple missions instead of 'throwing away' crew transportation, service modules, propulsion stages, and/or excursion systems after only a single mission. Furthermore, projects should lead to the development and demonstration (up to TRL 6) of novel approaches that enable 'energy rich' solutions to future space exploration challenges.

HESS projects should address one or more of the following strategic technical challenges (as defined in the H&RT Formulation Plan): (1) Reusability, (2) Energy-Rich Systems and Missions, (3) Modularity, (4) Reconfigurability, (5) Margins and Redundancy, (6) ASARA (as safe as reasonably achievable), and (7) Affordable Logistics Pre-Positioning. In particular, project proposals to the HESS element program are requested in the following areas (arranged by technical theme).

High-Energy, High-Efficiency, Low-Mass Solar Powered Systems. The affordable deployment of systems and logistics beyond low Earth orbit will depend on high-power, space transportation. In addition, a broad range of future systems and technologies will be constrained or enabled by the availability of (or lack of) significant power at an affordable cost. This area includes development of novel, high-power space systems; solar power generation and power management; and related thermal management systems that enable new class of space systems with power levels in the 100s of kWe or greater, with specific masses no more than 200 W/kg (i.e. a fraction of that of the International Space Station power systems).

Highly-Reliable/Autonomous Deep-Space Cryogenic Propellant Refueling Systems. The capability to pre-deploy propellants and other logistics will determine the feasibility of future reusable space exploration approaches. Technologies for the long-term in-space or planetary storage (e.g. zero boil-off), low-loss transfer, and effective management of cryogenic and other fuels.

High-Efficiency/Power and Low-Mass Electromagnetic (EM) Propulsion Systems. Enhanced ground test capability that accommodates the use of various propellants, lifetime testing of high-power EM propulsion systems, the examination of issues (e.g. stability) associated with multiple interacting thrusters, and end-to-end validation of integrated power/propulsion/thermal system stability.

Deep-Throttling Multi-Use In-Space Cryogenic Engines. Multi-use space transportation systems will be enabled only if high-energy, cryogenic propulsion can be developed (including LOx-Methane options as well as LOx-LH2). This area addresses small, deep-throttling cryogenic engines capable of many restarts and space-basing, with exceptionally high reliability.

Large, Low-Mass Aeroassist Systems. This area includes integrated low-mass, rigid aeroassist systems based on robust, high-temperature structures and adhesives, applicable to Moon/Mars Earth return and Mars deceleration scenarios. In addition, the areas of modular or deployable/inflatable aeroshells that enable scalable and reliable in-space assembly or deployment of large-diameter aeroassist systems.

Novel High-Energy Space Systems Demonstrations. This includes efficient end-to-end laser and/or microwave wireless power transmission systems, including power management and distribution, transmitters, and receivers.

Proposals concerning any of the above areas may involve the definition in preparation for later development of technology flight experiments, where such TFEs can be shown to be necessary to accomplish the technical goals and/or objectives of the proposed project. Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

2.2 Advanced Space Platforms and Systems (ASPS) Technology

Element Program Lead: Robert Wegeng (OExS) at robert.wegeng-1@nasa.gov

The Advanced Space Platforms and Systems (ASPS) Element Program examines a range of key technology options associated with future space exploration systems and architectures that are resilient, reliable and reconfigurable through the use of miniaturization, modularization of key functions in novel systems approaches. Platforms technologies that support self-assembly and in-space assembly, as well as in-space maintenance and servicing will be included. These efforts are coordinated with in-space assembly and related R&D within the Space Operations Technology Program (e.g., involving extra-vehicular activity (EVA) systems, robotics, etc.). Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- Intelligent Modular Systems
- Robust & Reconfigurable Habitation Systems
- Integrated System Health Management
- Communications Networks and Systems.
- Novel Platform Systems Concept Demonstrations

In response to this Intramural Call for Proposals, ASPS Projects are invited that will lead to the development and demonstration (up to TRL 6, including potential technology flight experiments) of novel technologies that enable future space exploration systems and architectures that are resilient, reliable and reconfigurable through the use of miniaturization and modularization of key functions in novel systems approaches. ASPS projects should address one of more of the following strategic technical challenges: (1) Modularity, (2) Autonomy, (3) "ASARA", (4) Reconfigurability, (5) Reusability, and (6) In-Space Assembly (with the greatest focus on self-assembly).

One of the central challenges for ASPS is to validate (or invalidate) by 2011 the systems-of-systems level concept of autonomous, self-assembly of modular systems/structures, which may only be realized through flight experiments/demonstrations.

The following challenges are of particular importance.

Intelligent Modular Systems. Technologies of interest include: Autonomous rendezvous and docking technologies; Reconfigurable, multi-functional robotic hardware and software. Integrated, reconfigurable structural modules incorporating multiple elements such as solar collection arrays, radiators, power, data, utility lines, science instruments, etc.

Robust and Reconfigurable Habitation Systems. Including Reusable, inflatable habitat structures based on common core structural habitat modules incorporating, for example, advanced metallic, composite and flexible fabrics; Multifunctional habitat structural materials, for example, including embedded sensors, power, radiation shielding, etc.; Airlock systems that incorporate novel methods of dust control for lunar and/or martian environments; Reconfigurable, reusable habitat life support technologies, including regeneration of oxygen.

Integrated System Health Management (ISHM). Technologies and integrated systems approaches of interest will include Integrated systems including sensors, software and computing to enable monitoring and management of diverse subsystems/systems.

Communications and Navigation Systems. Topics of interest will include open, non-proprietary communications architectures based on the internet, incorporating standard network IP protocols; and, Integrated high-rate communications, navigation and avionics technology, that can support accurate "dead-reckoning" between navigation fixes from single satellite contacts and celestial observations, based on local area network architectures.

Developments should focus on establishing the validity of new, space-based approaches to Earth-Moon operations, with a view toward longer-term applications for inner Solar System (e.g., the Mars) exploration missions. Technologies that address longer-term challenges are also of interest, but may be expected to be of lower overall emphasis in the resulting investment portfolio.

Proposals concerning any of the above areas may involve the definition in preparation for later development of technology flight experiments, where such TFEs can be shown to be necessary to accomplish the technical goals and/or objectives of the proposed project. Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

2.3 Advanced Space Operations (ASO)Technology

H&RT Element Program Lead: Nantel Suzuki at nantel.h.suzuki@nasa.gov

This Program Element examines a range of key technology options associated with future space exploration systems and architectures that are involve a variety of combinations of advanced robotic and human capabilities, ranging from remotely telesupervised robotic systems, through locally-teleoperated systems, to focused human presence (with robotic agent assistance). Technologies that enable in-space assembly, maintenance and servicing will be included. Key objectives will derive from the goals of safe/reliable, affordable and effective future human and robotic space exploration in support of the U.S. Vision for Space Exploration. These efforts will be closely coordinated with spacecraft subsystem, system, and related R&D within the Space Platforms and Systems Technology Program. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- Space Assembly, Maintenance and Servicing Systems
- Extravehicular Activity (EVA) Systems
- Intelligent and Affordable On-Board Operations Systems
- Reliable and Responsive Ground Operations Systems
- Novel Space Operations Demonstrations

One of the central strategic technical challenges for ASO is to validate (or invalidate) by 2011 the system-of-systems level concept of in-space assembly as it applies to a variety of advanced space operations systems. A key aspect of the challenge is to dock vehicles and systems together on orbit instead of launching pre-integrated exploration missions from Earth using very heavy launch vehicles, and enabling in-space maintenance, servicing, reconfiguration, evolution, etc., for exceptionally long-duration deep space operations.

ASO projects should address one or more of the following strategic technical challenges (as defined in the H&RT Formulation Plan): (1) In-Space Assembly (including 'self-assembling systems, in coordination with related developments in the Advanced Space Platforms and Systems Element Program), (2) Autonomy, (3) Reusability, (4) Modularity, (5) Reconfigurability, (5) Margins and Redundancy, and (6) Data-Rich Virtual Presence. In particular, project proposals to the ASO element program are requested in the following areas (arranged by technical theme). A proposal may address one or more of these areas.

Space Assembly, Maintenance and Servicing Systems. Areas of interest include fast, efficient, and precise in-space assembly systems at a large-scale (e.g. cranes), mid-scale (e.g. anthropomorphic robots), or small-scale (dexterous and/or micro manipulators), reliable in-space self deploying systems, and self-assembling systems for applications in Earth-orbit, the Moon, and beyond, including intelligent and robust docking mechanisms, as well as robust, autonomous rendezvous and docking technologies and test beds.

Extravehicular Activity (EVA) Systems. This area will be pursued in close coordination with related activities within NASA's Office of Biological and Physical Research

(OBPR). Within H&RT, topics of interest could include advanced EVA translation and mobility aids, and EVA power and hand tools.

Intelligent and Affordable On-Board Operations Systems. Technology areas of interest include reliable and timely automated space operations nominal/off-nominal procedure management systems, integrated and adaptable user interfaces, including intuitive displays, reliable speech interfaces, and consistent design approaches, and reliable, cost-effective in-flight mission training systems and environments

Reliable and Responsive Ground Operations Systems. Topics of potential interest include standardized ground and launch operations systems to limit life-cycle costs, novel mission operations systems approaches, and integrated ground test bed environments.

Typical projects in this Element Program will have a length of no more than 3 years (to conclude during FY 2008), following an initial pilot project of 1 year (in FY 2005) at the end of which time, a 'go/no-go' review will be held to determine the future continuation of the full project. A total of approximately 2-5 intramural ASO pilot projects may be created within the scope of available funds in FY 2005. The total scope (full 1 year pilot plus 3 years project) for individual ASO projects created through this ICP will range from approximately $10M to $20M, including a first year pilot effort (in FY 2005), which should not exceed 10-15% of the total value of the project. Note that all resource ranges stated above are full cost.

Proposals concerning any of the above areas may involve the definition in preparation for later development of technology flight experiments, where such TFEs can be shown to be necessary to accomplish the technical goals and/or objectives of the proposed project. Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

2.4 Lunar and Planetary Surface Operations (LPSO) Technology

Element Program Lead: Robert Wegeng (OExS) robert.wegeng-1@nasa.gov.

This Element Program examines a range of key technology options associated with future lunar and planetary surface exploration and operations for a range of increasingly-ambitious human and robotic mission options through the development of *in situ* resource utilization technologies, highly-capable surface mobility systems, and various supporting infrastructures. Key objectives are derived from the goals of safe/reliable, affordable and effective future human and robotic lunar and planetary surface exploration in support of the U.S. Vision for Space Exploration. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- Intelligent & Agile Surface Mobility Systems
- *In Situ* Resource Utilization Systems
- Surface Manufacturing and Construction Systems
- Surface Environmental Management Systems

In response to this Intramural Call for Proposals, LPSO Projects are invited that will lead to the development and demonstration (up to TRL 6, including potential technology flight experiments) of novel technologies associated with future lunar and planetary surface exploration and operations for a range of increasingly-ambitious human and robotic mission options through the development of in situ utilization technologies, highly-capable surface mobility systems, and various supporting infrastructures. LPSO projects should address one of more of the following strategic technical challenges: (1) Reusability, (2) Modularity, (3) Autonomy, (4) "ASARA", (5) Reconfigurability, (6) Robotic Networks, (7) Affordable Logistics Pre-positioning, (8) Space Resources Utilization, (9) Data-Rich Virtual Presence, and (10) Access to Surface Targets.

One of the central challenges for LPSO is to validate (or invalidate) by 2011 the systems-of-systems level concept of *in situ* resource utilization, especially for the production of oxygen and propellants from lunar resources.

The following challenges are of particular importance.

Intelligent & Agile Surface Mobility Systems. Topics of interest could include both Piloted and unpiloted rover technologies.

***In Situ* Resource Utilization Systems.** Technology areas of potential interest include excavation, extraction, collection beneficiation technologies for lunar and/or Martian resources. Includes solids and/or gases; reconfigurable, modular chemical process technologies for *in situ* oxygen and/or propellant production from lunar or mars resources; and technologies for *in situ* production of structural feedstock materials from lunar and/or Martian resources.

Surface Manufacturing and Construction Systems. Technologies of interest include those for the production of structural components using available lunar and/or Martian resources; autonomous or tele-operated robotic technologies for surface facility assembly and maintenance; and, technologies for the *in situ* manufacture of solar photovoltaic systems.

Surface Environmental Management Systems. Technologies of interest include natural, mechanical, electromechanical and/or electrical dust removal/mitigation technologies, including multifunctional systems or dust-control elements that are embedded within other systems.

Developments should focus on establishing the validity of new, space-based approaches to Earth-Moon operations, with a view toward longer-term applications for inner Solar System (e.g., the Mars) exploration missions. Technologies that address longer-term challenges are also of interest, but may be expected to be of lower overall emphasis in the resulting investment portfolio.

Typical projects in this Element Program will have a length of no more than 3 years (to conclude during FY2008), following an initial pilot project of 1 year (in FY2005) at the end of time, a 'go/no go' review will be held to determine the future continuation of the full project. A total of approximately two to four (2-4) intramural LPSO pilot projects may be created within the scope of available funds in FY2005. The total scope (full 1 year pilot plus 3 years project) for individual ASPS Projects created through this ICP will range from $10M to $20M, including a first year pilot effort (in FY2005), which should not exceed 10-15% of the total value of the project. Note: All resource ranges stated above are full cost.

Proposals concerning any of the above areas may involve the definition in preparation for later development of technology flight experiments, where such TFEs can be shown to be necessary to accomplish the technical goals and/or objectives of the proposed project. Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

2.5 In-Space Technology Experiments Program (In-STEP)

Element Program Lead: Carlos Campos (OExS) at carlos.s.campos@nasa.gov

The In-Space Technology Experiments Element Program (In-STEP) will pursue both low to mid- TRL flights of novel technologies, where appropriate, in addition to supporting the development and deployment (where required) of key infrastructures and carriers for such technology flight experiments (TFEs). The In-STEP effort will engage not only the other element programs within the H&RT Technology Maturation Program, but also possible TFEs emerging from the Advanced Space Technology Program and a range of other key technology options associated with future human and robotic space exploration and operations. Key objectives are derived from the goal of technology validation in support of safe/reliable, affordable and effective systems and missions in support of the U.S. Vision for Space Exploration. Proposals are sought in the technical themes listed below. A proposal may address one or more of these themes.

- Technology Flight Experiment (TFE) Definition
- Technology Flight Experiment Accommodations
- Technology Flight Experiment Development
- Technology Flight Experiment Integration, Launch and Operations

The InSTEP program will enable the timely identification, development and flight of important experiments (at TRL 5 or lower) in space to validate novel technology applications, as well as occasional larger-scale and/or higher fidelity demonstrations incorporating multiple technologies in new, interdisciplinary systems concepts. In general, InSTEP will work in close concert with other H&RT programs, providing flight opportunities for lower TRL technologies emerging from the ASTP, as well as defining and flying TFEs related to technology maturation efforts that are cross-cutting in character. Major InSTEP technical activities invited through this ICP include the following topics.

Technology Flight Experiment (TFE) Definition and Development. This theme will address the array of technology disciplines incorporated within the H&RT family of programs ASTP, TMP and ITTP). Technology flight experiment definition studies should relate clearly to ASTP or to ITTP—as well as cross-cutting TFEs related to developments within the TMP. (Any proposed activities not clearly derived from one of these sources should provide detailed information supporting a clear linkage to priority goals and objectives of H&RT and space exploration technology needs.

Technology Flight Experiment Accommodations, Launch and Operations. This technical theme will include assessments of carriers, launch opportunities, and preliminary planning for in-space accommodation of TFEs. It will also include activities related to the integration, launch and operation of future H&RT technology flight experiments. This topic may include TFEs derived from ASTP, TMP or ITTP. Specific activities invited under this ICP should relate to preliminary studies to determine requirements and options for technology flight experiment accommodations and flight.

Specific guidance concerning scope, duration of projects, etc., is provided below in Section D.

3. Innovative Technology Transfer Partnerships (ITTP) Program

Program Director, Benjamin Neumann (OExS), at benjamin.j.neumann@nasa.gov

3.1 Technology Transfer (TT)

Program Manager, Jack Yadvish (OExS) at John.R.Yadvish@nasa.gov

This Element Program supports the timely transfer of technology into and out of the full suite of NASA's applied research, technology and development programs. Major TT technical themes include the following:

- NASA Field Center Technology Transfer Offices
- Regional and National Technology Transfer Centers
- NASA Intellectual Property (IP) Efforts
- Special Technology Transfer Projects

Technology Transfer proposals are invited under this solicitation for the purpose of funding partnerships with industry. Specific objectives of these proposals should be for the validation and maturation of thjose technologies of that support space exploration needs. In particular, technology themes of interest include those defined by the AST and TM Programs in sections 1 and 2 of this ICP.

As examples, we are seeking partnerships that take NASA developed technology and enhance their manufacturability, which can result in a useable product or system for NASA's project constellation. Also, technologies that have been developed by industry for their commercial purposes and can be enhanced through validation for space application or matured to become space qualified are all within the scope of this solicitation.

Proposals of interest include technologies that NASA may have funded under the SBIR and STTR programs and successfully completed phase-II are eligible for tech transfer intramural proposals. This solicitation is separate and unrelated from the SBIR and STTR program solicitations. Also, Tech Transfer solicitation under this ICP should not be used as an alternative to a normal acquisition. It is presumed that funded proposal will utilize the Space Act Agreement (or similar mechanism) with the industry partner.

Details concerning funding for these areas, including both scope and duration will be developed through separate coordination with the ITTP Program Director.

3.2 Small Business Innovation Research (SBIR)

Program Manager, Carl Ray (OExS) at carl.g.ray@nasa.gov

This Element Program provides an opportunity for small business-based innovators to become involved with NASA's R&D investment portfolio. SBIR serves the interests of all of NASA strategic Enterprises. Major SBIR technical themes include the following:

- Technologies to Enable Human and Robotic Exploration
- Technologies to Advance Earth System Science and Understanding of the Sun-Earth Connection
- Technologies to Improve U.S. Aviation Systems and Operations

All proposed activities within this Element Program will be established through ongoing SBIR program solicitations, not through this ICP.

3.3 Small Business Technology Transfer (STTR)

Program Manager, Carl Ray (OExS) at carl.g.ray@nasa.gov

This Element Program provides an opportunity for advanced technologies and new concepts to be transitioned more effectively and more rapidly from the university community to small business-based innovators and then to NASA's R&D investment portfolio. STTR serves the interests of all of NASA strategic Enterprises. Major STTR technical themes include the following:

- Technologies to Enable Human and Robotic Exploration
- Technologies to Advance Earth System Science and Understanding of the Sun-Earth Connection
- Technologies to Improve U.S. Aviation Systems and Operations

All proposed activities within this Element Program will be established through ongoing STTR program solicitations, not through this ICP.

C. Eligibility Requirements

Only NASA Centers are eligible to submit proposals in response to this ICP (The Jet Propulsion Laboratory is considered a NASA Center for the purposes of this call). NASA investigators may, however, collaborate with other NASA Centers as well as universities, federal Government Laboratories, the private sector, and state and local government laboratories.

D. Project Duration and Other Award Information

Proposals submitted in response to this ICP must describe a complete 2-phase research and development (R&D) plan. However, a key product of the first phase of each selected project will be a detailed plan for the implementation of the remainder of the project.

Initial awards under this NRA will be for Phase I R&D for no longer than 12 months, and will typically range from 10-15% of the total cost of the full project. Only the most promising Phase I projects will be selected for continuation to Phase II, an additional funding period for the completion of the project. Continuation at the end of Phase 1 will be contingent upon availability of funds and adequate progress toward project progress milestones as determined by NASA management.

Within the ASTP Program, project scope will be for a value/period up to the following limits:

ASTP Element Program	Maximum Phase I + Phase II Duration
ASCT Tools and Databases (Section B.1.1)	12 months + 36 months, with a total value (per project) of between $4M-$8M
ASCT Concepts and Studies (Section B.1.1)	12 months + 12 months, with a total value (per project) of between $2M-$4M
Other ASTP Element Programs (Sections B.1.2-B.1.5; including Advanced Materials and Structural Concepts; Computing, Electronics and Imaging Systems; Software, Intelligent Systems and Modeling; and Power, Propulsion and Chemical Systems)	12 months + 36 months, with a total value of between $5M-$15M

(Note: a proposed ASTP project may fail to be accepted for being outside the planned scope of H&RT; this may include projects that are either too large or too small in funding scope, take too long to complete, or which are otherwise inconsistent with the goals and objectives of ASTP and H&RT.)

Within the TMP Program, project scope will be for a value/period up to the following limits:

TMP Element Program	Maximum Phase I + Phase II Duration
InSTEP projects that support the initial defiition and design studies related to development of key infrastructures and carriers (Section B.2.5)	12 months + 12 months, with a total value (per project) between \$2M-\$4M
InSTEP Technology Flight Experiment Definition Studies and Implementation (Section B.2.5)[2]	12 months + 36 months, with a total value (per project) of between \$10M-\$20M (not including launch)
Other TMP Element Programs (Sections B.2.1-B.2.4; including High Energy Space Systems; Advanced Space Platforms and Systems; Advanced Space Operations; and Lunar/ Planetary Surface Operations)	12 months + 36 months, with a total value (per project) of between \$10M-\$40M

(Note: a proposed TMP project may fail to be accepted for being outside the planned scope of H&RT; this may include projects that are either too large or too small in funding scope, take too long to complete, or which are otherwise inconsistent with the goals and objectives of TMP and H&RT.)

Details concerning funding for activities in the area of ITTP/Technology Transfer activities, including both scope and duration will be developed through separate coordination with the ITTP Program Director, following approval of any submitted Notices of Intent (NOIs).

E. Use of Human and/or Animal Subjects

For H&RT projects employing human subjects and/or animals, assurance of compliance with human subjects and/or animal care and use provisions is required. While such assurance need not be included in proposals responding to this ICP, selected projects that employ human and/or animal subjects will be required to provide the appropriate certification(s) prior to the release of funds.

F. Proposal Preparation and Submission

1. Notice of Intent Preparation, Submission, and Review

NASA investigators planning to submit a proposal in response to this call are required to submit a notice of intent (NOI) to propose. All NOIs must be delivered by email attachment to **noi@hq.nasa.gov** by **4:30 PM EDT, May 21, 2004**. The Subject of each NOI email should read "H&RT ICP," and each NOI should include the following:

[2] During Phase I, InSTEP technology demonstration projects are expected to define carrier requirements.

- Project Lead Last Name
- Project Lead First Name
- Proposal Title
- Project Lead Organization (i.e., NASA Center)
- H&RT Program (i.e., Advanced Space Technology, Technology Maturation)
- Primary Element Program (see Section B)
- Secondary Element Program (if applicable)
- Expected Participating NASA Centers and Other Collaborating Institutions (if applicable) [This information is non-binding]
- Preliminary Estimates (± 20%) of both the budgetary scope (i.e., total project cost) and the average number of FTEs over the entire project duration (i.e., rounded to the nearest FTE)
- Brief summary (i.e., 500 words or less); This summary will serve as the Proposal Abstract.

An NOI template that may be completed and submitted by email attachment is provided at http://research.hq.nasa.gov/code_t/icp/index.html.

Within 5 working days of the NOI submission deadline, H&RT personnel will complete a preliminary review based primarily on relevance to the H&RT Theme. Only those NOIs that successfully complete this review will be eligible for subsequent proposal submission.

2. Proposal Preparation and Submission

One (1) signed original proposal and fifteen (15) copies of the proposal **must be received by 4:30 PM EDT, June 14, 2004**. Proposals shall not be submitted electronically. Proposals mailed through the U.S. Postal Service by express, first class, registered, or certified mail are to be sent to the following address:

NASA Peer Review Services
SUBJECT: H&RT ICP
500 E Street SW
Suite 200
Washington, DC 20024

Proposals that are hand delivered or sent by commercial delivery or courier services are to be delivered to the above address between 8:00 a.m. and 4:30 p.m. Proposals must be received by 4:30 p.m. Eastern time on the proposal due date. The telephone number, (202) 479-9030, may be used when required for reference by delivery services. NASA Peer Review Services (NPRS) cannot receive deliveries on Saturdays, Sundays, or federal holidays. NPRS will send notification to the investigator confirming proposal receipt within 5 business days of the proposal receipt date; however, there will not be a response from H&RT.

Proposals should be bound only by metal staples or metal binder clips. **The proposal must include the following material, in this order:**

(1) Proposal Cover Page: An electronic Cover Page template, as well as other applicable forms, is provided at http://research.hq.nasa.gov/code_t/icp/index.html. This Cover Page includes the proposal title; the name, institution, and contact information for the PI and each collaborator; the applicable H&RT Program(s) and Element Program(s) (see Section B); and the signature of the PI and the NASA Center authorizing official. Note that the authorizing official will typically be a line manager or equivalent, and the level of authorization will be sufficient to commit center resources.

(2) Executive Summary: A brief summary of the proposed project including justification on how the proposed research and development satisfies the unique requirements of H&RT.

(3) Project Description: The length of the Project Description section of the proposal cannot exceed 8 pages using regular (12 point) type. Text should have the following margins: left = 1.5"; Right, top, bottom = 1.0." Referenced figures must be included in the 8 pages of the Project Description. Bibliographical information should be included following the Project Description, but is not considered part of the 8-page limit. Management Approach, and all following sections are also not considered part of the 8-page project description. Proposals that exceed the 8-page limit for the Project Description may not be reviewed. The proposal should contain sufficient detail to enable reviewers to make informed judgments about the overall merit of the proposed research and about the probability that the investigators will be able to accomplish their stated objectives with current resources and the resources requested. In addition, the proposal should clearly indicate the relationship between the proposed work and the research emphases defined in this call. Reviewers are not required to consider information presented as appendices or to view and/or consider Web links in their evaluation of the proposal. The Project Description should include, at a minimum, the following subsections:

- Introduction and Background Information
- Objectives, including Specific Aims
- Approach and Methodology
- Deliverables

(4) Management Approach: (up to 4 pages) Each proposal must specify a single NASA Principal Investigator who is responsible for carrying out the proposed project and coordinating the work of other personnel involved in the project. In proposals that designate several senior professionals as key participants in the research project, the management approach section should define the roles and responsibilities of each participant and note the proportion of each individual's time to be devoted to the proposed research activity. The proposal must clearly and unambiguously state whether these key personnel have reviewed the proposal and endorsed their participation.

The Management Approach section should also include a Work Breakdown Structure (WBS) detailing a schedule of milestones and deliverables consistent with the (1-year, Phase I + 3-year, Phase II) structure outlined in Section D of this call. The typical objective of projects funded in ASTP will be to reach a TRL of 4 to 5 by project completion in 2008. Within the ASCT Element Program (described in Section B), this guideline only applies to Tools; Studies and Concepts funded through the ASCT Element Program will typically reach lower TRLs by project completion in 2008. The typical objective of projects funded in TMP will be to reach a TRL of 6 by project completion in 2008. This guideline does not apply to the InSTEP Element Program (described in Section B).

(5) Personnel/Biographical Sketches: The biographical sketch for each investigator should not exceed two pages. If the list of qualifications and publications exceeds two pages, select the most pertinent information. List, in chronological order, the titles, all authors, and complete references to all publications pertinent to this application (see Guidebook for Proposers). Provide biographical information only for senior professional personnel who will be directly associated with the project. Provide the names and titles of any other scientists and technical personnel associated substantially with the project in an advisory capacity.

(6) Facilities and Equipment: Describe the available facilities and major items of equipment specially adapted or suited to the proposed research activities, and any additional major equipment that will be required. Identify any government-owned facilities, industrial plant equipment, or special tooling that are proposed for use in the research activities. The research plan must provide evidence that such facilities or equipment will be made available if the proposal is accepted.

(7) Budget and Supporting Budgetary Information: A Budget Form is provided at http://research.hq.nasa.gov/code_t/icp/index.html. Using this form, please provide budget information, in full-cost accounting, for each year proposed. In addition to the Budget Form, please provide up to 2 pages of Supporting Budgetary information text, including a plan for commitment, obligation, and costing of funds. This plan should be consistent with industry standard earned value management practices.

(8) Other Support: An “Other Support Form” is provided at http://research.hq.nasa.gov/code_t/icp/index.html. Using this template, please provide information on specific sources of other active and pending support for the principal investigator and each co-Investigator.

(9) Appendices, if any (**reviewers are not required to consider information presented in appendices**).

G. Proposal Review and Selection

1. Technical Merit Review

The first review tier will be a merit review by a panel of scientific and technical experts consisting primarily of non-NASA personnel. The merit review panel will assign *a score from 0-100* based upon the intrinsic technical merit of the proposal. This score will reflect the consensus of the panel. The following factors will be considered in the evaluation and scoring of a proposal:

- Relevance and potential to support H&RT goals and objectives.
- Technical quality and appropriateness of the proposed effort, including the technical approach and the clarity and appropriateness of technical milestones and proposed accomplishments, and identification of appropriate technology metrics characterizing advances to be achieved.
- Appropriateness of the proposed team and management, including relevant experience, including qualifications and depth of management and technical staff and past performance, as well as proposed teaming with other NASA Centers[3] and, where appropriate, with non-NASA organizations.
- Reasonableness of proposed project resources and implementation planning, as well as the appropriateness and clarity of planning for project financial and progress reporting (based on Earned Value Management System (EVMS) principles).

2. Integration Panel

Upon completion of the technical merit review panels, an integration panel consisting of representatives from each of the individual panels as well as NASA program management will meet. The integration panel will consider the findings of the technical merit panels, as well as overall program balance and budget, in the preparation of selection recommendations.

3. Selection

The selection recommendation prepared by the integration panel will be submitted to the Deputy Director for Human and Robotic Technology, Development Programs Division, within the Office of Exploration Systems who will serve as the selecting official.

[3] See Section A.3 concerning the importance of appropriate partnerships among NASA Centers.